Effect of sectioning the Acromioclavicular and Coracoclavicular Ligaments in the Shoulder Complex Motion: A Whole Cadaver Study

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ABSTRACT INTRODUCTION:
Dislocation of the acromioclavicular joint is a common injury among young athletes. Many previous studies have evaluated the acromioclavicular joint function by measuring the motion of clavicle and acromion [1]. However no report has ever referred to its function on the whole shoulder girdle. In this study, we measured and compared the motion of the shoulder girdle (scapula, clavicle and humerus) relative to the thorax of nine cadaveric shoulders after sectioned the acromioclavicular and coracoclavicular ligaments sequentially.

METHODS:
The IRB of our institute approved all methodological procedure in this study. Five fresh whole cadavers (age 61-90 years old; 2 female and 3 male) were used. We did not find complete rotator cuff tear, osteoarthritis of the glenohumeral joint, or severe degenerative change in the sternoclavicular and acromioclavicular joint. One shoulder was excluded due to limited range of motion so total of 9 shoulders were analyzed.

A six degrees of freedom electromagnetic tracking device (3Space Fastrak, Polhemus, Colchester, Vermont) was used. The accuracy of the system is 0.8 mm for position and 0.15 degree for orientation. The devices were placed on the spinous process, scapula, humerus and clavicle with transarticular pins.

For each shoulder, we sectioned the acromioclavicular (AC) ligament, trapezoid ligament (TR) ligament and conoid (CO) ligament sequentially. We stabilized the cadavers in sitting position on a wooden stool without interrupting the scapular motion (Fig. 1). Before experiments, we manually elevated the arms of the specimens 5 times in all planes to release the contracture of the shoulders. Prior to sectioning of the ligaments, we identified the AC ligament, sternoclavicular joint and coracoclavicular ligaments with minimal skin incision and splitting of the pectoralis major. Scapulothoracic motions during arm movements in 4 planes (coronal, sagittal, scapular and horizontal planes) were monitored. Each motion was repeated 3 times. Kinematics of the scapula and clavicle were measured in following 4 conditions; 1. intact, 2. section of the AC ligament, 3. additional section of the TR ligament, 4. additional section of the CO ligament.

For the thorax, scapula and humerus, we set axis alignment of each bone segment based on the International Society of Biomechanics recommendation [2]. Clavicuilar, scapular and humeral motions were described with use of the Cardan and Euler angles relative to the thorax. We calculated scapulothoracic angle during the humerothoracic elevation angles from 20 to 120 degrees and the humerothoracic horizontal adduction angles from 20 to 100 degrees.

The reliability of the three trials at each humeral elevation angle was calculated for each variable with use of intraclass correlation coefficients. One-way analysis of variance was used to test the differences in these 4 conditions. Turkey-Kramer post hoc testing was used for multiple pairwise comparisons.

RESULTS:
The averaged intraclass correlation coefficients for trial-to-trial reliability were 0.99, 0.98, 0.88 in the scapular motion for the humerothoracic motions in the sagittal, scapular, and, coronal plane elevation and horizontal adduction respectively.

In the AC ligament sectioned model, compared with the intact model, scapular posterior tilting decreased in the end of horizontal adduction (> 90 degrees, Fig 2B). In the AC and TR ligaments sectioned models, scapular internal rotation increased in horizontal adduction (> 45 degrees, Fig 2C) and scapular posterior tilting decreases in horizontal adduction (> 50 degrees, Fig 2B). In the AC, TR and CO ligaments sectioned model, compared with the intact model, scapular posterior tilting decreased in sagittal plane elevation (> 85 degree, Fig 2A) and horizontal adduction (> 35 degrees, Fig 2B). Scapular internal rotation increased in all phase of adduction (20-100, Fig 2C). In addition, compared with the TR sectioned model, scapular internal rotation increased (> 35 degrees) and scapular posterior tilting increased (> 60 degrees).

DISCUSSION:
Scapular dyskinesis is an important complication in the patients with Rockwood type 3 acromioclavicular dislocation [3]. Our study revealed that coracoclavicular ligaments are important restraint against scapular anterior tilting and internal rotation. In addition, the result indicated that only trapezoid ligament disruption can lead to anterior tilting and internal rotation of the scapula in humerothoracic horizontal adduction. A wide variety of operative procedures have been described for acromioclavicular joint injury [4]. Most of them aim to achieve stability for anteroposterior and horizontal translation. Our result, however, suggested that rotational instability should be corrected to prevent scapular dyskinesis and incongruity of the acromioclavicular joint.

SIGNIFICANCE
The coracoclavicular ligaments were important restraints against scapular internal rotation and anterior tilting especially in humerothoracic horizontal adduction and sagittal plane elevation.

REFERENCES: